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bright lines or short bright spaces between broad absorption bands; I believe the former. There are certainly two bright spots (lines appear as spots with the apparatus used), one probably in the green, much plainer than the other, which is half-way from it to the red end. I strongly suspect a third at an equal distance on the other side of the brightest. The general appearance of the whole spectrum of star and nebula is very much like that of an ordinary comet.

November 5.—There can be no doubt the spectrum of the new star is highly interrupted, and I have little doubt it contains more than one definite bright line. The brightest is about at the brightest part of the spectrum of the nebula, which is continuous as far as I can see, though there may be brighter bands in its centre, but this suspected appearance may only be caused by the star's spectrum.

1886, *February* 1.—I think the spectrum of the nucleus of the nebula is not simply continuous, but has two or three or more bright bands on it; this may, however, be only imagination.

1887, *December* 7.—The spectrum of the nebula is certainly mainly continuous, though I suspect a bright line in the brightest part as well as other very slight irregularities, but I cannot be sure of any of them.

December 10.—With a low power the spectrum mostly appears quite continuous, though I sometimes have a faint suspicion of a very feeble line or lines.

All the above observations were made with a Browning miniature spectroscope on a 4¼-inch refractor by Cooke; the following was made without any telescope, merely using one or two prisms of dense flint glass, both with and without spectacles in addition:—

1887, *December* 9.—The spectrum seems perfectly continuous, without the slightest sign of any lines, a great contrast to that of the Great Nebula in *Orion* which, viewed in this manner, consists of two conspicuous bright lines.

Sunderland: 1887, *December* 22.

The Chief Meteor Showers. By W. F. Denning.

I have derived from my observations during the last fifteen years the following mean places for the radiants of the leading showers. The positions are corrected for precession, and brought up to 1890:—

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Name of Shower.	Duration.	Date of Max.	Radiant Point. α	δ	Sun's Longitude.
Quadrantids	Dec. 28–Jan. 4.	Jan. 2	229°·8	+ 52°·5	281°·6
Lyrids	April 16–22	April 20	269·7	+ 32·5	31·3
η Aquarids	April 30–May 6	May 6	337·6	− 2·1	46·3
δ Aquarids	July 23–Aug. 25	July 28	339·4	− 11·6	125·6
Perseids	July 11–Aug. 22	Aug. 10	45·9	+ 56·9	138·5
Orionids	Oct. 9–29	Oct. 18	92·1	+ 15·5	205·9
Leonids	Nov. 9–17	Nov. 13	150·0	+ 22·9	231·5
Andromedes	Nov. 25–30	Nov. 27	25·3	+ 43·8	245·8
Geminids	Dec. 1–14	Dec. 10	108·1	+ 32·6	259·5

Notes.

Quadrantids.—Heis was the first to determine this radiant accurately. It was subsequently observed by Masters and Prof. Herschel (1863–4). The radiant is circumpolar in this latitude, but low down during the greater part of the night, hence the display is usually seen to the best advantage on the morning of Jan. 2.

Lyrids.—Attention was first drawn to the April meteors by Herrick in the United States (*B. A. Report*, 1871, p. 42). The probable identity of this meteor orbit with Comet I., 1861, was pointed out by Galle and Weiss. The earlier observers of this stream placed the radiant too far N.E., and the assumed accordance was therefore considered doubtful. My recent observations prove that the radiant is identical with that computed for the comet of 1861, and it exhibits a displacement to the E., as observed on successive nights. Prof. Herschel gives the cometary radiant as 270°·5 + 32°, April 20, Corrigan, 270°·9 + 33°·5.

η *Aquarids.*—Further observations are urgently required of this stream. The radiant is only visible for a short time before sunrise. There is a considerable difference between my results and those secured by Col. Tupman, the discoverer of this system in 1870, whose observations place the radiant at 326½ − 2½ April 29–May 3. These May Aquarids are interesting from the fact that they present an orbital resemblance to Halley's Comet which makes a near approach to the earth on May 4, twelve days before reaching the descending node. (See *Monthly Notices*, xlvi. p. 396–8.)

δ *Aquarids.*—The meteoric epoch, July 26–30, was first pointed out by Quetelet many years ago. Biot also found, from the oldest Chinese observations, a general maximum between July 18 and 27 (Humboldt). Showers of Aquarids were remarked by Schmidt, Tupman (1870), and others, but it was not known until observations in 1878 by the writer that the Aquarids formed the special display of the epoch, and that there were many early Perseids visible at the same time.

Perseids.—Muschenbroeck, in his work on "Natural Philosophy," printed in 1762, mentions that he observed shooting stars to be more numerous in August than in the other months of the year. Quetelet, in 1835, was, however, the first to attribute a definite maximim to the 9th–10th. This stream is remarkable for its extended duration, and for the obvious displacement which occurs from night to night in the place of its radiant (see *Monthly Notices*, xlv. pp. 97–8). The period of visibility appears to cover the forty-three nights from July 11 to August 22 inclusive, and the radiant advances from 11° + 48° to 76° + 57°. This shower apparently varies but little in its annual richness. In the morning of August 11 it usually yields from sixty to eighty meteors per hour for one observer. The centre of radiation on August 10 agrees with the

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radiant assigned to Comet III., 1862, viz. $43^\circ + 57^\circ{\cdot}5$ (Herschel), and $43^\circ{\cdot}8 + 57^\circ{\cdot}2$ (Corrigan).

Orionids.—Profs. Schmidt and Herschel were the first to discover the Orionids as the most brilliant display of the October period, and accurately determined its radiant in 1863-4-5. Herrick recorded a shower at $99^\circ + 26^\circ$, Oct. 20-26, 1839, and Zezioli in 1868 recorded many meteors which were ascribed to a radiant at $111^\circ + 29^\circ$, but there is no doubt that the Orionids were observed in both these cases, though the radiant was badly assigned. There is a contemporary shower at $106^\circ + 22^\circ$, close to δ *Geminorum*, which is liable to be confused with the Orionids, but the latter is by far the richest of the pair. The radiant of the Orionids shows no displacement like the Perseids.

Leonids.—Observed from the earliest times. Humboldt and Bonpland saw it well on the night of November 11-12, 1799, and the phenomenon at its magnificent return on November 12, 1833, was ably discussed by Olmsted. It furnished a splendid shower in 1866, November 13, and many meteors were seen at the few subsequent returns. During the last fifteen years the displays have been extremely meagre. There is no doubt, however, that the meteors form a complete ellipse, for the earth encounters a few of the particles at every passage through the node. But the meteors are nearly all massed in the neighbourhood of their parent, Comet I. 1866, which gives a radiant at $150{\cdot}5 + 23{\cdot}5$, November 13 (Herschel), and $150^\circ{\cdot}4 + 22^\circ{\cdot}8$ (Corrigan). It is supposed that there are minor groups of meteors pursuing the same orbit; if so we may have a revival of this display in 1888, for "on the night of November 12, 1822, shooting stars mingled with balls of fire were seen in vast numbers at Potsdam by Klöden" (Lardner's *Museum*).

Andromedes.—Observed by Brandes, at Hamburg, December 7, 1798. It also recurred in 1838; the very brilliant showers of November 27, 1872 and 1885, are still fresh in the memory. It is uncertain whether this group forms an unbroken stream; if so, the regions far removed from the comet must be extremely attenuated. Some of the meteors were seen in 1877 and 1879. The radiant is diffuse to the extent of 7° or 10°. The cometary radiant is at $23^\circ{\cdot}4 + 43^\circ{\cdot}4$ (Weiss), and $24^\circ + 43^\circ{\cdot}2$ * (Corrigan), which is very close to the meteoric centre. Returns of the shower should be looked for in 1892 and 1898.

Geminids.—Mr. Greg first called attention to the importance of this shower. It was well observed by Prof. Herschel in 1861-3-4, and some later years.

Bristol: 1887, December.

Heights of Fireballs and Shooting Stars. By W. F. Denning.

While occasionally engaged during the past year in computing meteor heights, I was led to compare the relative elevations of fireballs and ordinary shooting stars. The former before extinction appear to penetrate much lower in the air than the latter. From the real paths of the fireballs and smaller meteors seen by myself and other members of the Liverpool Astronomical Society at the end of 1886 and during 1887, it appears that the height of fireballs at disappearance is only about one-half that of shooting stars, the figures being 25 and 54 miles respectively. But these values are based on only 20 observations, and are, therefore, far from being conclusive. They are, however, amply

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* These positions by Mr. Corrigan are taken from the *Sidereal Messenger*, May 1886.